EFFECTS OF METERING IN AND OUT TO THE PERFORMANCE OF HYDRO-PNEUMATIC DRIVELINE FOR DUAL HYBRID SYSTEM.

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DECLARATION

I declare that this project report entitled “Effects of Metering In and Out to The Performance ff Hydro-Pneumatic Driveline For Dual Hybrid System” is the result of my own work except as cited in the references

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APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Structure & Materials).

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Date : 20 JUNE 2021

DEDICATION

To my beloved family who have given me an endless support,

Also my supervisor En. Faizil Bin Wasbari

&

Dearest friends

ABSTRACT

Hybrid Hydraulic Vehicle (HHV) is quite popular in automotive industry for hybrid technology. However, the system is facing a problem in controlling the RPM since HHV has limited storage energy to store high-pressure thus it results to unstable behavior of RPM and only able to operate in short period of time. Therefore, the aim of this study is to determine the RPM profile behavior with metering in and out and also to compare the result between without metering and with metering in and out. The circuit diagram is designed and simulated by using the hydraulic tool in the Automation Studio software. A simulation towards both systems in the hydro-pneumatic driveline is carried out to observe the behavior of RPM. For system with metering, a flow control valve with check valve is installed before and after the hydraulic motor to be metered in and out. Besides, pressure storage inside the accumulator will be vary from 120 bar until 220 bar to observe the behavior of RPM in the hydro-pneumatic driveline and data will then be taken out. Through the simulation, metering in and out shows better performance compared to a system without metering since metering in and out has proved that the system can effectively control the behavior of RPM. The peak reading of radial speed for system with metering in and out is 2809.48 rpm and the discharge time is 8.2 s which is the radial speed is lower and the discharge time is longer than a system with no metering. This discharge time is good to power mild and medium type of hybrid system.

ABSTRAK

Kenderaan Hidraulik Hibrid (KHV) cukup popular dalam industri automotif untuk teknologi hibrid. Namun, sistem ini menghadapi masalah dalam mengendalikan RPM kerana KHV mempunyai tenaga simpanan yang terhad untuk menyimpan tekanan tinggi sehingga mengakibatkan tingkah laku RPM yang tidak stabil dan hanya dapat beroperasi dalam jangka waktu yang singkat. Oleh itu, tujuan kajian ini adalah untuk menentukan tingkah laku profil RPM dengan permeteran masuk dan keluar dan juga membandingkan hasil antara tanpa permeteran dan permeteran masuk dan keluar. Gambarajah litar direka bentuk dan disimulasikan dengan menggunakan alat hidraulik dalam perisian Studio Automasi. Simulasi terhadap kedua-dua sistem dalam pemanduan hidro-pneumatik dilakukan untuk memerhatikan tingkah laku RPM. Untuk sistem dengan pemeteran, injap kawalan aliran dengan injap periksa dipasang sebelum dan sesudah motor hidraulik yang akan diukur masuk dan keluar. Selain itu, penyimpanan tekanan di dalam akumulator akan bervariasi dari 120 bar hingga 220 bar untuk mengamati perilaku RPM dalam pemanduan hidro-pneumatik dan data kemudian akan dikeluarkan. Melalui simulasi, permeteran masuk dan keluar menunjukkan prestasi yang lebih baik berbanding dengan sistem tanpa permeteran kerana pemeteran masuk dan keluar telah membuktikan bahawa sistem dapat mengawal tingkah laku RPM dengan berkesan. Bacaan puncak kelajuan radial untuk sistem dengan pengukuran masuk dan keluar adalah 2809.48 rpm dan masa pelepasan adalah 8.2 s yang mana kecepatan radialnya lebih rendah dan masa pelepasan lebih lama daripada sistem tanpa pemeteran. Masa pelepasan ini baik untuk memberi kuasa kepada sistem hibrid jenis ringan dan sederhana.

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LIST OF ABBREVIATIONS

HHV	Hybrid Hydraulic Vehicle
HEV	Hybrid Electric Vehicle
ICE	Internal Combustion Engine
DCV	Directional Control Valve
TBW	Throttle by Wire

LIST OF SYMBOLS

P	Power
Q	Flowrate
P	Pressure
N	Revolution per Minute
T	Torque

CHAPTER 1

INTRODUCTION

1.1 Background

In this era of globalization, hybrid technology has been widely used in the field of automotive because it was known for its energy-saving, environmentally friendly, and also more efficient compared to conventional vehicles (Wasbari et al., 2016). A hybrid road vehicle is one that used energy of propulsion, during the designated operations, where it has exceeded two or more kinds or types of energy stores, sources, or converters. To summarize, hybrid vehicles apparently consist a combination of an Internal Combustion Engine with an energy storage/energy converter, which it allows to give additional power for the vehicle to propel and receive energy when regenerative braking takes place.

Hybrid vehicle comes in with two types, which that need to be considered, such as Hybrids Electric Vehicles (HEV) and Hybrid Hydraulic Vehicles (HHV) (Boretti & Secki, 2012). HEV uses a motor-generator as a power unit and it also uses propulsion to convert kinetic energy to electrical energy and stores the energy in a battery pack. According to *newsroom.toyota.eu*, Toyota alone has passed 15 million hybrid electric vehicles global sales up until January 2020. While for HHV, it stores the kinetic energy captured when the regenerative braking occurs or the energy produced by the ICE in hydro-pneumatic accumulators and returns this energy during the vehicle cruising. For a large range of medium-sized vehicles, such as urban delivery trucks, shuttle/transit buses and waste disposal vehicles, hydraulic hybrid technology has important commercial potential. The ICE and hydraulic motor are used as propulsion by the hydraulic hybrid technology, while the hydro-pneumatic accumulator serves as power storage. The regenerative takes energy from braking and coasting and converts it into compression energy. After that, the hydro-pneumatic accumulator plays its role to store the energy as a potential energy (P.E.). However, there are some disadvantages of HHV where it has low energy density but high-power density. This means HHV can deliver a big amount of energy in short periods of time but small energy in long periods of time. This will eventually affect rotational speed for propulsion system and lead to inconsistency of RPM. Hence, metering in and metering out is introduced to control the behaviour of the RPM.

Consequently, this project focuses on controlling the unstable and inconsistency of RPM. Therefore, parameters will be set up and a circuit diagram will be designed and simulated by using Automation Studio software to observe the profile and behaviour of RPM.

1.2 Objectives

- To determine the behaviour of flow, system pressure, and pressure losses to the RPM of the propulsion system.
- To determine the behaviour of metering in and out on the performance of hydro-pneumatic propulsion system.
- To compare the speed, power and torque between basic control with metering in and out.

1.3 Scope of Project

The scope of this project is merely focused on the hydraulic system only which includes the effects of metering in and out. Some simulations will be carried out to determine the functional of the hydraulic system.

1.4 Problem Statement

The usage of hybrid technology has been spread worldwide along with its improvement. Despite that, the research for development of the hybrid technology is still ongoing and none of the research has focused on the development of the effects of metering in and out towards hydro-pneumatic performance. Based on the current testing rig, the system is having a problem in controlling RPM where the initial is too high and it is receding from time to time. This is because of hydraulic system has a limited storage energy which once the energy dropped, the RPM will be dropped as well. The speed of flow needs to be controlled since speed and torque are the main factor in the propulsion system. Hence, the approach of meter-in and meter-out is used in this study project.

1.5 Hypothesis

With the new method of controlling RPM which is metering in and metering out will be tested with perhaps to minimize the inconsistency of RPM during initial rotation and also to maintain the RPM. This experiment will be conducted with respect to the hydro-pneumatic for a dual hybrid to ensure the effectiveness of the metering in and out in order to cater the system efficiency with optimum performance.

CHAPTER 2

LITERATURE REVIEW

2.1 Hybrid

Conventional vehicle or known as gasoline car has major implications for environmental pollution, health, and dependency on fossil fuels which will result in global warming caused by an increasing volume of generated CO_2 (Bansagi & Toth, 1977). Hence, the invention of hybrid is introduced widely in worldwide. A hybrid vehicle is a system that uses propulsion energy from two types of energy source or more where it consist of ICE combined with an energy storage device, which is capable of returning the energy for propelling the vehicle and receiving energy when braking the vehicle (Boretti & Zanforlin, 2014).

2.2 Hybrid Hydraulic Vehicles

Hybrid Hydraulic Vehicles (HHV) use a power source where engine and hydraulic are combined together to produce its power for vehicles to accelerate. In HHV, a hydraulic pump is used to replace the electric motor as the driving force while the accumulator will act as the energy storage tank. According to (Incorvia, 2015), the accumulator will act when a hydraulic pump/motor is integrated into the system. HHV's accumulator power capacity may largely exceed and surpass the power of thermal engines in heavy and light-duty truck applications. Therefore, the braking capacity of HHV is theoretically unlimited. HHV are also known to have better regenerative braking efficiencies compared to HEV. (Boretti &

Zanforlin, 2014) stated that, of 100% vehicle kinetic energy, 80% is the captured braking energy, 77.6% is the stored energy available for acceleration, and 71% is the energy returned to the wheels.

Hydraulic Hybrid consists mainly of high-pressure and low-pressure accumulators. High-pressure accumulators can operate up to 135 bar till 485 bar while for low pressure it can occasionally operate between 3.5bar and 13.5 bar. A hydraulic power unit supplies oil from the low pressure accumulator to the high pressure accumulator. During the high-pressure process, a nitrogen bladder is compressed because the fluid flows into the accumulator, and nitrogen pressure level rises (Wohlgemuth & Wachtmeister, 2013). The kinetic energy that is lost by heat and friction is captured and then stored in the accumulator. **Figure 2.1** shows the configuration of the HHV accumulator.

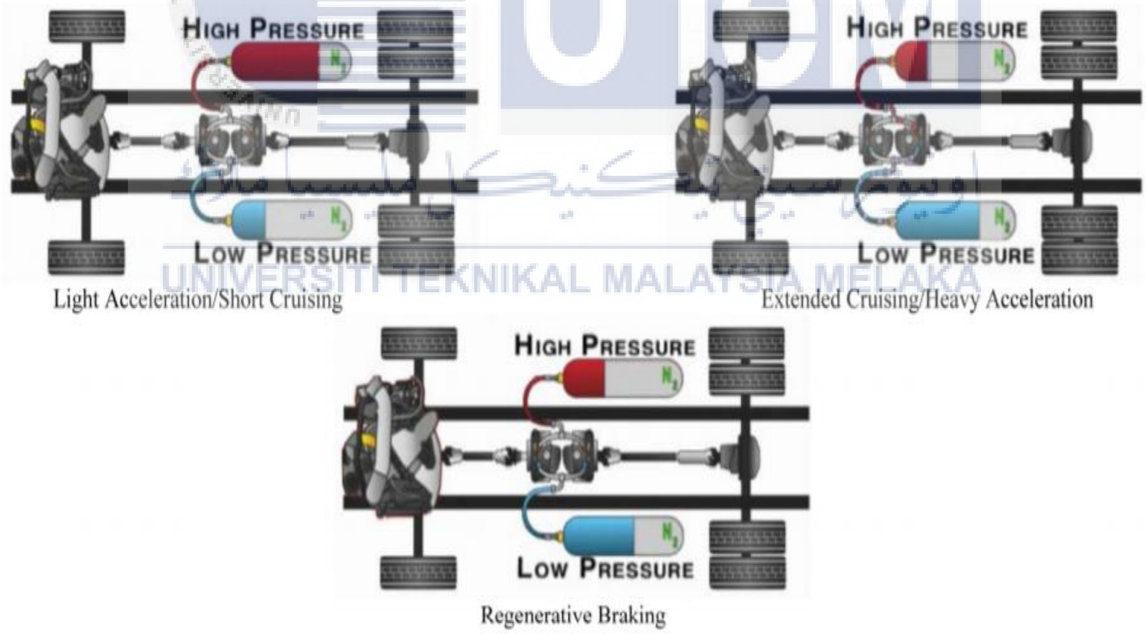

Figure 2.1: Configuration of HHV accumulator

2.3 Hydro-pneumatic Driveline

Hydro-pneumatic is a system that is used as hybrid propulsion and secondary propulsion unit where it is normally applied by the heavy vehicle. Hydro-pneumatic has good properties such as damping and its task to reduce and to isolate the suspended part of the vehicle by dampening the vibrations in very different operating conditions (Borghi et al., 2017).

A hydro-pneumatic consists of two systems which are pressurized air and water. It contains no bladder and air that is directly in contact with the water. Cushion exerting and pressure absorbing will occur when the compressed air starts to act. There are three different types of mechanisms in hydro-pneumatic where it provides water within a selected range so that the pump does not run continuously, prevents the pump from operating every time there is a slight call for water from the distribution system, and also to minimize pressure surge.

2.4 Type of Propulsion

Propulsion is defined as an action or mechanism of pulling or pushing an object to move forward. Propulsion originally comes from two Latin words, which means before or forward to drive the object away. There is a source of mechanical power in a propulsion system (some sort of motor or engine, muscles) and a means of using that power to produce force, such as wheels and axles, propellers, propulsion nozzles, wings, fins, or legs. In Newton's third laws of motion, he stated that there is an equal and opposite reaction for every action (force) that occurs in any system. There are a few types of propulsion systems that need to be taken into consideration, such as internal combustion engines, electrical motors, hydraulic motors.

2.4.1 Internal Combustion Engines

Internal Combustion Engines (ICE) can be defined as a heat engine in which the heat source is a combustible mixture that also serves as the working fluid. In turn, the working fluid is used either by moving the piston or turbine blade that turns drives to produce the shaft work or generating a high momentum fluid used directly for propulsive force. **Figure 2.2** shows the configuration of internal combustion engines. ICE is the most commonly used for power generating machines which include gasoline engines, diesel engines, gas turbine engines, and rocket-propulsion system. Internal combustion engines fall into two categories, which are continuous combustion engines and intermittent engine combustion engines. A continuous combustion engines basically uses a turbine as a working system where it simply exhausts its gas continuously rather than in a cycle while for intermittent combustion engines, it uses a piston as working system and is characterized by periodic ignition of air and fuel and is commonly referred as to as reciprocating engine (Encyclopedia, 2020).

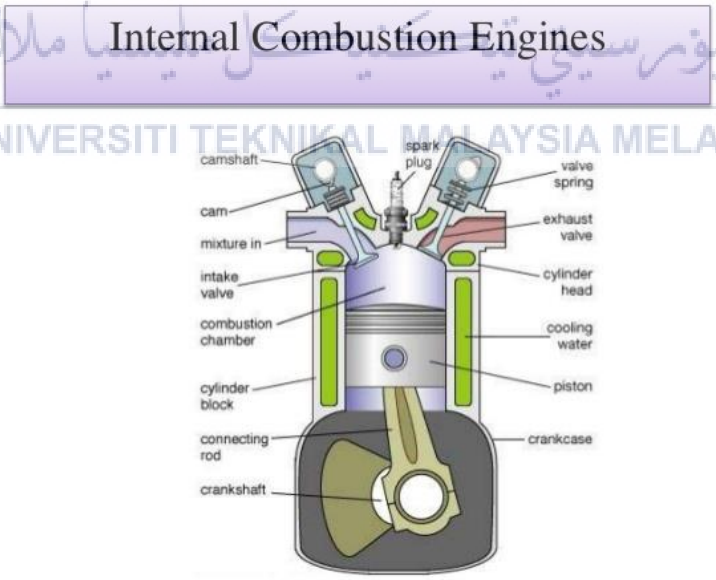

Figure 2.2: Configuration of internal combustion engines